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(54) **COOLED LED LIGHTING APPARATUS**

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F21V 29/67	(2015.01)
F21V 29/65	(2015.01)
F21S 4/00	(2006.01)
F21Y 105/00	(2006.01)

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(58) **Field of Classification Search**
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See application file for complete search history.

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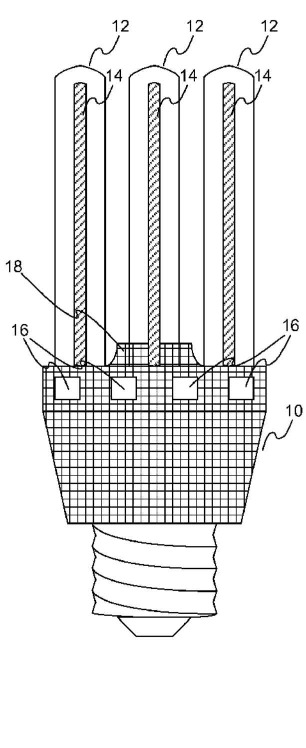
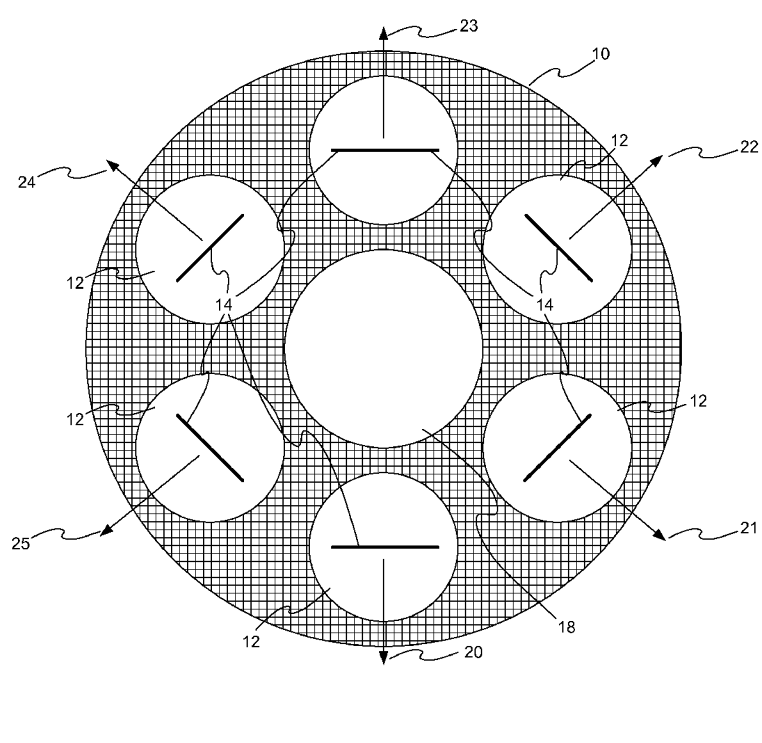
(57) **ABSTRACT**

A light emitting diode ("LED") lighting apparatus has vents to cool the LED lighting apparatus. The LED lighting apparatus comprises one or more strips, a base having vents, and one or more glass tubes. Each strip has LEDs and a transparent backing. The vents comprise a central vent and side vents, were the central vent and certain ones of the side vents are connected to allow for gas flow. The one or more strips and the one or more glass tubes are coupled to the base, where the one or more glass tubes encapsulate the one or more strips. The central vent is disposed adjacent to the one or more glass tubes, and a heat transfer medium within selected ones of the one or more glass tubes flows out of the selected ones of the one or more glass tubes for cooling.

12 Claims, 7 Drawing Sheets





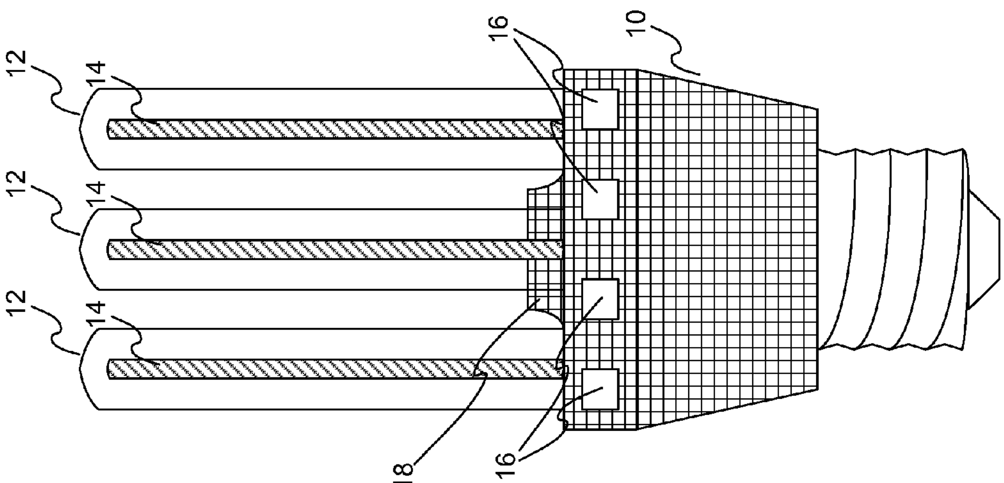


Fig. 1

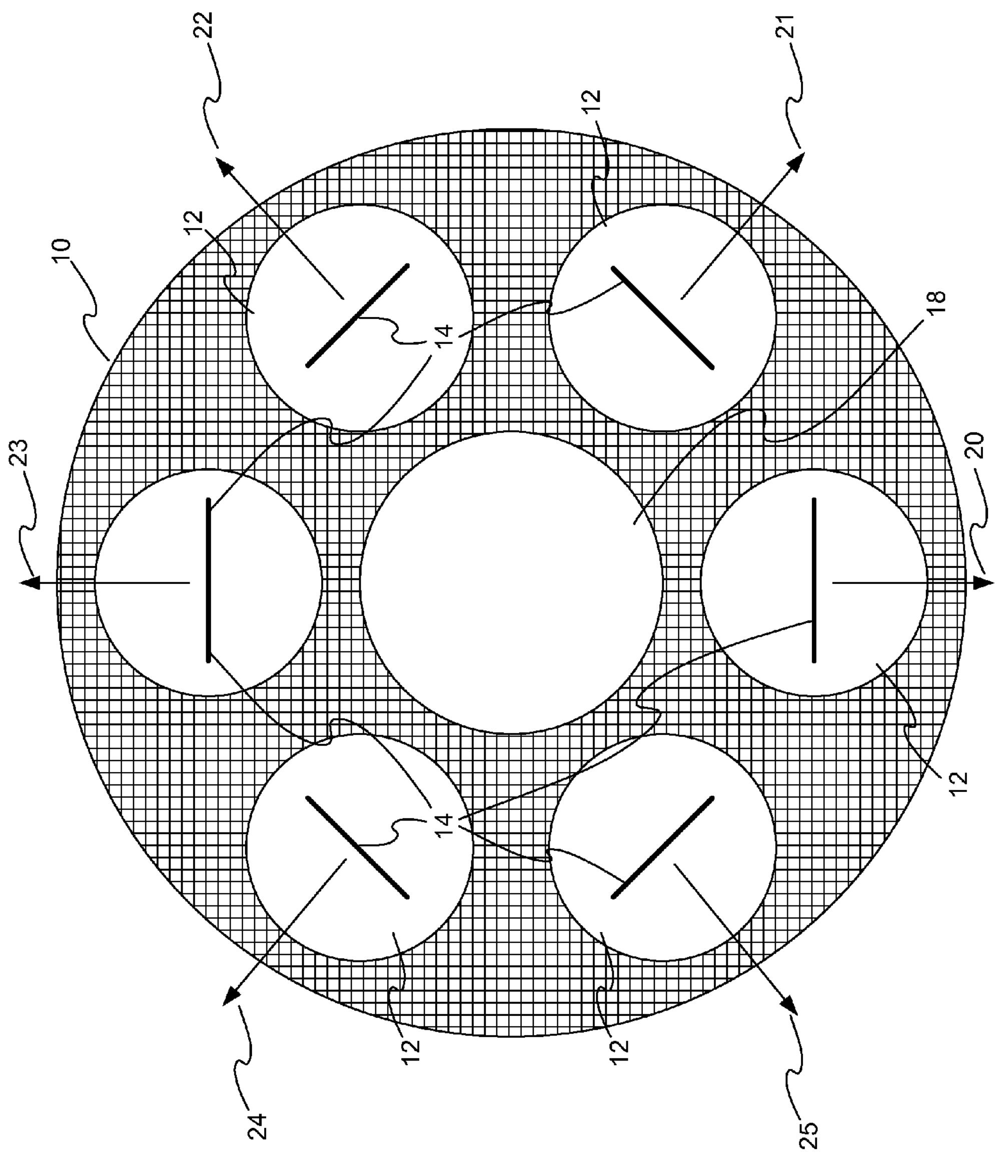


Fig. 2

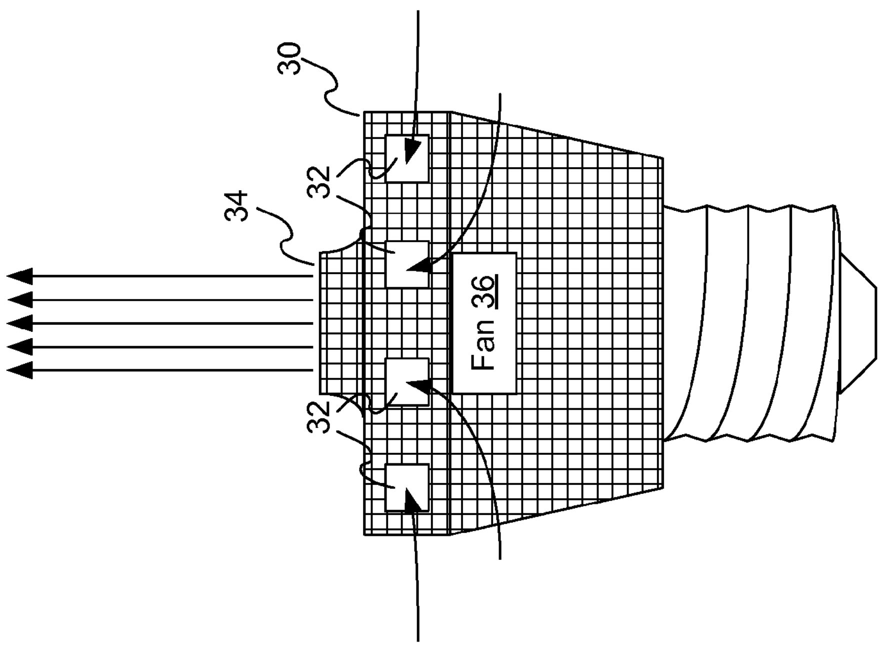


Fig. 3a

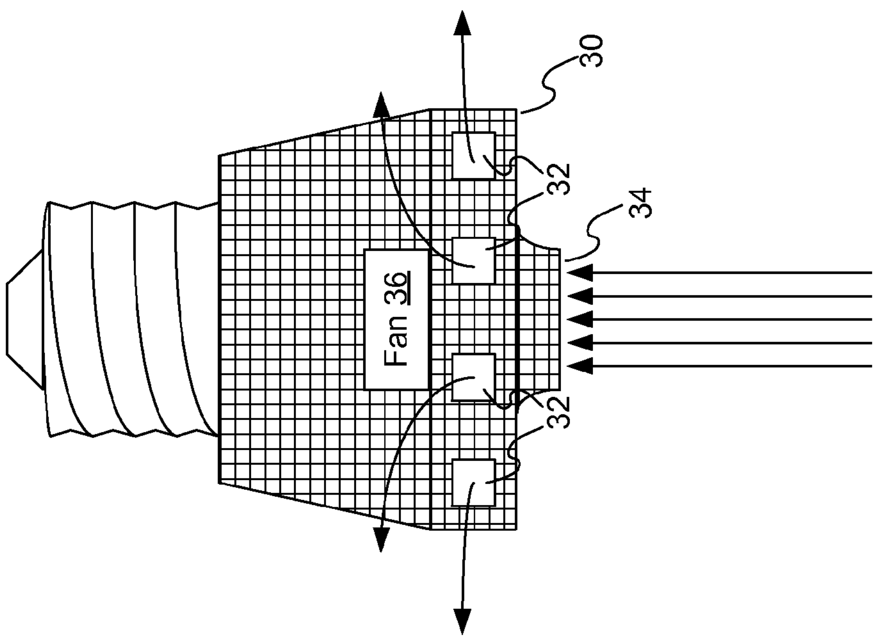


Fig. 3b

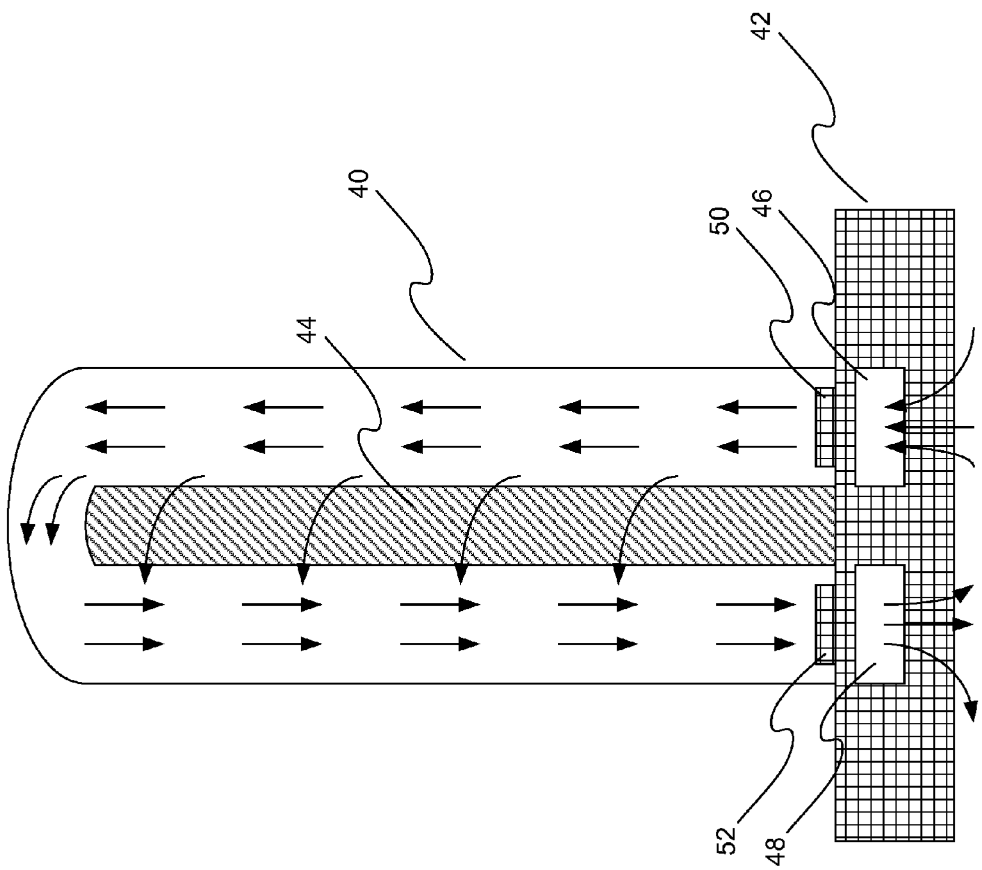


Fig. 4

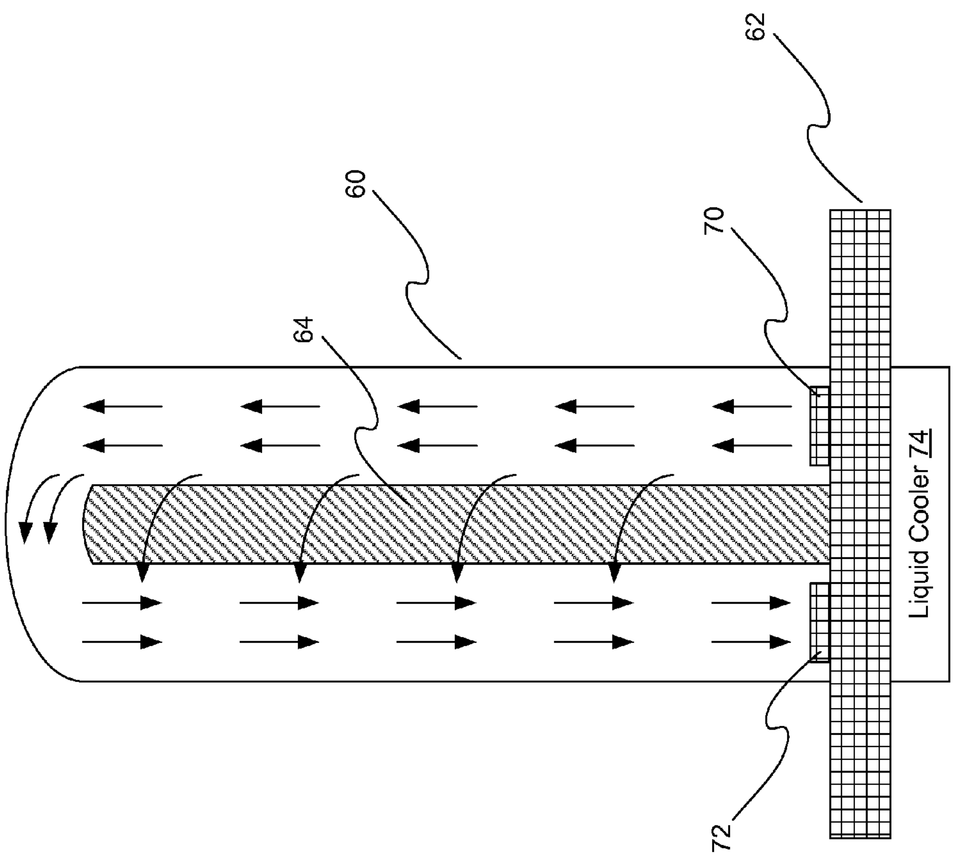


Fig. 5

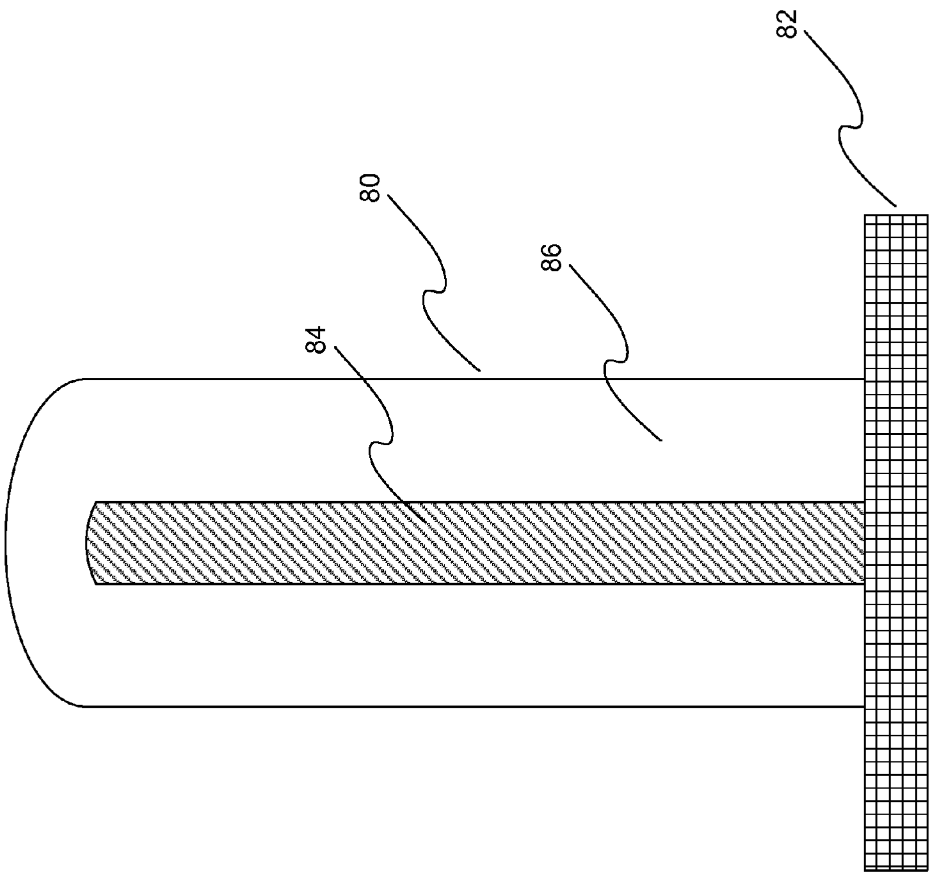


Fig. 6

COOLED LED LIGHTING APPARATUS

FIELD OF INVENTION

The disclosure relates to methods, systems, and apparatuses for light emitting diode lighting, and, more particularly, to methods, systems, and apparatuses for cooling light emitting diodes.

BACKGROUND

A light emitting diode ("LED") is a semiconductor light source, which has a longer lifetime, faster switching, smaller physical size, greater durability and higher energy efficiency than current day lighting devices, e.g., fluorescent lights bulbs or incandescent light bulbs. When an LED is forward biased, electrons (negative charges) recombine with holes (positive charges), releasing energy in the form of photons. The energy difference between the electrons and holes of the LED produces photons of different wavelengths. Certain wavelengths provide for specific visible colors. Thus, the LED does not require color filters to produce any specific colors.

Generally, LEDs are solid state devices, and if operated at low currents and at low temperatures, are subject to limited device wear and tear. Lifetimes of LEDs are anywhere from around five to fifty times longer than fluorescent light bulbs and incandescent light bulbs. LEDs are also less susceptible to damage than fluorescent and incandescent light bulbs.

LEDs produce more light per watt than incandescent bulbs, and are ideal for use in applications that are subject to frequent on-off cycling, unlike fluorescent lamps that burn out more quickly when cycled frequently. LEDs can very easily be dimmed continuously unlike fluorescent lamps which require a certain threshold voltage to maintain illumination.

LEDs have been found to have significant environmental benefits compared to other alternatives. For instance, a building's carbon footprint from lighting can be significantly reduced by exchanging all incandescent bulbs for LED light bulbs. LEDs are also non-toxic compared to fluorescent light bulbs, which contain traces of mercury.

Performance of LEDs is temperature dependent, and LED light output can actually increase at lower temperatures. LEDs do not generate as much heat as incandescent bulbs, but LEDs do produce internal heat which must be dissipated if the LED is to maintain good performance and low temperatures. Conversely, over-heating LEDs can lead to major device failure.

In order to combat overheating of LEDs, LED lights have incorporated heat sinks to dissipate heat generated by the LEDs. Heat sinks are widely available for LEDs, but any improvement in cooling can increase device operations and reliability. Some heat sinks are made by simply having a number of cooling fins connected to the LEDs. However, these designs are bulky, aesthetically unpleasing, and expensive to build LED light bulbs.

Therefore, it is desirable to develop new methods, systems, and apparatuses for cooling LED lighting (e.g., LED light bulbs, LED lamps, and other LED lighting apparatuses) to increase performance and maintain a long lifespan for the LEDs.

SUMMARY OF INVENTION

Briefly, the disclosure relates to a light emitting diode ("LED") lighting apparatus, comprising: one or more strips, wherein each of the one or more strips has LEDs and a transparent backing; a base having vents, wherein the vents

comprise a central vent and side vents and wherein the central vent and certain ones of the side vents are connected to allow for gas flow; and one or more glass tubes, wherein the one or more strips and the one or more glass tubes are coupled to the base, wherein the one or more glass tubes encapsulate the one or more strips, wherein the central vent is disposed adjacent to the one or more glass tubes, and wherein a heat transfer medium within selected ones of the one or more glass tubes flows out of the selected ones of the one or more glass tubes for cooling.

DESCRIPTION OF THE DRAWINGS

The foregoing and other aspects of the disclosure can be better understood from the following detailed description of the embodiments when taken in conjunction with the accompanying drawings.

FIG. **1** illustrates a side view of an LED lighting apparatus having vents to cool the LEDs.

FIG. **2** illustrates a top view of an LED lighting apparatus having a central vent.

FIGS. **3***a*-**3***b* illustrate side views of a base of an LED lighting apparatus having a central vent and side vents.

FIG. **4** illustrates an LED lighting apparatus using gas cooling.

FIG. **5** illustrates an LED lighting apparatus using liquid cooling.

FIG. **6** illustrates an LED lighting apparatus using compressed gas for cooling an LED lighting apparatus.

DETAILED DESCRIPTION OF THE EMBODIMENTS

In the following detailed description of the embodiments, reference is made to the accompanying drawings, which form a part hereof, and in which is shown by way of illustration of specific embodiments in which the disclosure may be practiced.

FIG. **1** illustrates a side view of a light emitting diode ("LED") lighting apparatus having vents to cool the LEDs. An LED lighting apparatus comprises a base **10**, LED strips **14**, and glass tubes **12** that encapsulate the LED strips **14**. The base **10** has vents **16** and **18** to allow gas (or other heat transfer medium, including air, liquid, etc.) flow through the base **10** from one side of the base **10** to another side of the base **10** or to within the glass tubes **12**. The LED strips **14** comprise LEDs interconnected to a backing, where the backing is coupled to the base **10**. The coupling can be by mechanical interlocking means, soldering, or by other coupling means. The base **10** is electrically connected to the LED such that the base **10** can receive an input voltage and drive the LEDs of the LED strips **14**. For instance, the base **10** can be screwed into a light socket, where the light socket provides a voltage that is routed to the LED strips **14** via the base **10**. It is understood by a person having ordinary skill in the art that the LED lighting apparatus can have electrical components to receive an input voltage and drive the LEDs of the LED strips **14**. For instance, the base **10** may have well known circuitry to boost, rectify, regulate, and/or otherwise alter the voltage from the light socket before being inputted to the LED strips **14**. A person having ordinary skill in the art is aware of such circuitry. Thus, the present disclosure also includes such electrical circuitry to operate the LED lighting apparatus.

When the LED strips **14** are activated, i.e., the LEDs are on, heat is generated. The generated heat is transferred to the glass tubes **12**. The gas flow through vents **16** and **18** of the base **10** can be directed along the glass tubes **12** to cool the glass tubes **12**. Thereby, the LED strips **14** can be cooled by using the glass tubes **12** to transfer the heat away from the LED strips **14**. The vents **16** and **18** are bidirectional in that gas can flow either into the vent or out of the vent. The side vents **16** are located at the sides of the base **10** and away from the LED strips **14**. The central vent **18** is located in between the LED strips **14**. The gas near the side vents **16** are generally cooler than the gas near the central vent **18** since the LED strips **14** generate heat and are closer to the central vent **18**. The central vent **18** can be connected to the side vents **16** such that the gas near the side vents **16** can be directed and expelled through the central vent **18** or gas near the central vent **18** can be directed and expelled through the side vents **16**. Furthermore, a fan (not shown and an optional component) can be located in the base **10** along the gas flow to increase gas flow through the vents **16** and **18**.

In an example, as the gas between the glass tubes **12** is heated up, cooler gas near the side vents **16** can travel through the base **10** and out through the central vent **18** to circulate out the heated gas and to cool the exterior walls of the glass tubes **12**. Conversely, depending on the orientation of the LED lighting apparatus, the heated gas can travel through the central vent **18** and out to the side vents **16** to allow for cooler gas to circulate across the glass tubes **12**.

In another example, certain ones of the vents **16** can be connected directly to the encapsulated portions of the glass tubes **12**. In his manner, a heat transfer medium, e.g., gas, can circulate from outside the LED lighting apparatus to the encapsulated portions of the glass tubes **12**. Also, the heat transfer medium within the encapsulated portions of the glass tubes **12** can be expelled out of the glass tubes with a cooler heat transfer medium being circulated into the glass tubes **12**.

In yet another example, the heat transfer medium can be liquid. Here, certain ones of the glass tubes **12** can contain liquid to increase the heat transfer from the LEDs of the LED strips **14** to the glass tubes **12**. Furthermore, a liquid cooling unit (not shown and an optional component) can be disposed in the base **10** to further cool the liquid within the glass tubes **12**. The liquid within the encapsulated portions of the glass tubes **12** can be expelled out of the glass tubes to the liquid cooling unit to be cooled, and then the cooled liquid can be recirculated back into the glass tubes **12**.

FIG. **2** illustrates a top view of an LED lighting apparatus having a central vent. In a top view, the central vent **18** can be located in between the glass tubes **12**. The LED strips **14** within the glass tubes **12** can be positioned such that the LED strips **14** have LEDs facing in different directions, e.g., directions **20-25**, to increase the light distribution from the LED lighting apparatus. The backing on the LED strips can also be transparent such that the LEDs can emit light in the directions **20-25** and opposite directions relative to the directions **20-25**.

FIGS. **3*a*-3*b*** illustrate side views of a base of an LED lighting apparatus having a central vent and side vents.

FIG. **3*a*** illustrates the base of the LED lighting apparatus positioned in an upward orientation. The LED lighting apparatus is illustrated without glass tubes and LED strips in order to emphasize gas flow through a base **30** of the LED lighting apparatus. However, the present disclosure is not limited by this figure since it is understood that any number of glass tubes and LED strips can be coupled to the base **30**.

The base **30** can have vents **32** and **34** and a fan **36** to promote gas flow. Depending on the environmental conditions near the LED lighting apparatus (e.g., the direction of gravity, ambient temperature(s), and/or other environmental conditions) and the fan's blowing direction, heated gas can flow upwards with cooler gasses from the side vents **32** entering the base **30** and circulating to the central vent **34**. This orientation can be referred to as an upward orientation of the LED lighting apparatus. The fan **36** can increase the gas flow through the vents **32** and **34** by pumping additional gas up through the central vent **34**.

FIG. **3*b*** illustrates the base of the LED lighting apparatus positioned in a downward orientation. In another example, the orientation of the LED lighting apparatus can be positioned such that the heated gas can circulate through the central vent **34** and out the side vents **32**. This orientation can be referred to as a downward orientation. The fan **36** can also aid in the gas flow by pumping the heated gas from the central vent **34** to be expelled by the side vents **32**.

FIG. **4** illustrates an LED lighting apparatus using gas cooling. An LED lighting apparatus comprises a base **42** having vents **46-52**, a glass tube **40**, and an LED strip **44**. The glass tube **40** is coupled to the base **42**, encapsulating the LED strip **44** within the glass tube **40**. The vent **46** allows gas to enter the base **42** and enter the glass tube **40** via the internal vent **50**. The vent **48** allows gas within the glass tube **40** to be expelled via the internal vent **52**. In order to aid in the understanding of the present disclosure, a single glass tube and a single LED strip are shown. This is not meant to limit the present disclosure. In fact, it is understood that the LED lighting apparatus may have additional vents, glass tubes, LED strips, and/or use one or more cooling methods as desired.

The gas within the glass tube **40** can be circulated to the outside of the LED lighting apparatus via the vents **48** and **52**. Cooler gas can be circulated from the outside area relative to the LED lighting apparatus to inside the glass tube **40** via the vents **46** and **50**. In particular, the vents **52** and **48** are connected such that gas can flow into one vent and out the other vent. The vents **46** and **50** are also connected such that gas can flow into one vent and out the other vent. Furthermore, the vents **46-52** are bidirectional. Thus, the reverse gas flow for each pair of vents can also occur.

In one scenario, gas can flow into vent **46**, and then into the glass tube **40** via the internal vent **50**. The gas inside the glass tube **40** can flow out at the vent **48** via the vent **52**. It is important to note that additional vents can be used based on the present disclosure. Therefore, the present illustration is not meant to limit the present disclosure to two vents for each of the glass tubes. In fact, it is understood by a person having ordinary skill in the art that additional vents can be added to increase gas flow to and out of the glass tube. The LED lighting apparatus using gas cooling can also comprise other methods for cooling the LEDs, including those described in the present disclosure.

FIG. **5** illustrates an LED lighting apparatus using liquid cooling. An LED lighting apparatus comprises a base **62** having vents **70-72**, a glass tube **60**, an LED strip **64**, and a liquid cooling unit **74**. The glass tube **60** is coupled to the base **62**, encapsulating the LED strip **64** within the glass tube **60**. The vent **70** allows liquid to flow into the glass tube **40**. The vent **72** allows the liquid within the glass tube **40** to be expelled. The expelled liquid can be cooled by the liquid cooling unit **74**. The cooled liquid is connected to the vent **70** for returning back into the glass tube **70**. In this manner, heat can be dissipated from the LED strip **64** by circulating the cooled liquid from the liquid cooling unit **74**. In order to aid in the understanding of the present disclosure, a single glass tube and a single LED strip are shown. This is not meant to limit the present disclosure. In fact, it is understood that the LED lighting apparatus may have additional vents, glass tubes, and LED strips as desired.

The vents **70-72** are bidirectional. Thus, the reverse liquid flow for the pair of vents can also occur. For instance, liquid can flow out the vent **72** to the liquid cooling unit **74** to be cooled. The cooled liquid is circulated back into the glass tube **40** via the vent **70**. It is important to note that additional vents can be used based on the present disclosure. Therefore, the present illustration is not meant to limit the present disclosure to two vents for each of the glass tubes. In fact, it is understood by a person having ordinary skill in the art that additional vents can be added to increase liquid flow to and out of the glass tube. The LED lighting apparatus using liquid cooling can also comprise other methods for cooling the LEDs, including those described in the present disclosure.

The liquid can be pigmented to allow for a colored indicator to indicate the temperature of the LEDs of the LED lighting apparatus. For instance, the liquid can be colored various shades of yellow to indicate a relative temperature for the LEDs of the LED lighting apparatus.

The liquid can also be pigmented to change the emitted color of the LED lighting apparatus to approximate one or more predefined colors. For instance, if the LED strip emits a blue-ish light, the liquid can have a yellowish pigment to give a warmer yellow color to the emitted light. Furthermore, the emitted light can be strobed between various colors by altering the pigments in the liquid.

FIG. **6** illustrates an LED lighting apparatus using compressed gas for cooling an LED lighting apparatus. In another embodiment, an LED lighting apparatus comprises a base **82**, a glass tube **80**, an LED strip **84**, and compressed air **86**. The compressed air **86** can serve to increase the heat transfer between the LEDs of the LED strip **84** and the glass tube **80**. The LED lighting apparatus using compressed gas for cooling the LEDs can also comprise other methods for cooling LEDs, including those described in the present disclosure.

In various embodiments of the present invention, various combinations of cooling methods can be used together in the same lighting apparatus. Referring to FIG. **2** as an example, two of the glass tubes **14** can use a gas cooling method of the present disclosure, two other ones of the glass tubes **14** can use a compressed gas method of the present disclosure, and the remaining two glass tubes **14** can use a liquid cooling method of the present disclosure. Furthermore, combinations thereof the cooling methods of the present disclosure can be used as well.

While the disclosure has been described with reference to certain embodiments, it is to be understood that the disclosure is not limited to such embodiments. Rather, the disclosure should be understood and construed in its broadest meaning, as reflected by the following claims. Thus, these claims are to be understood as incorporating not only the apparatuses, methods, and systems described herein, but all those other and further alterations and modifications as would be apparent to those of ordinary skilled in the art.

We claim:

1. A light emitting diode ("LED") lighting apparatus, comprising:
- one or more strips, wherein each of the one or more strips has LEDs and a transparent backing;
- a base having vents, wherein the vents comprise a central vent and side vents and wherein the central vent and certain ones of the side vents are connected to allow for gas flow; and
- one or more glass tubes,
- wherein the one or more strips and the one or more glass tubes are coupled to the base,
- wherein the one or more glass tubes encapsulate the one or more strips in a heat transfer medium, and
- wherein the central vent is disposed adjacent to the one or more glass tubes.

2. The LED lighting apparatus of claim **1** wherein the heat transfer medium is gas, and wherein the gas circulates via select ones of the side vents.

3. The LED lighting apparatus of claim **1** wherein the heat transfer medium is a liquid.

4. The LED lighting apparatus of claim **3** further comprising a liquid cooling unit, wherein the liquid is circulated to the liquid cooling unit for cooling, and wherein the cooled liquid is recirculated to the one or more glass tubes.

5. The LED lighting apparatus of claim **1** wherein the heat transfer medium is compressed air.

6. The LED lighting apparatus of claim **1** further comprising a fan, and wherein the fan drives gas through the central vent.

7. A light emitting diode ("LED") light bulb, comprising:
- one or more strips, wherein each of the one or more strips has LEDs and a transparent backing;
- a base having vents, wherein the vents comprise a central vent and side vents and wherein the central vent and certain ones of the side vents are connected to allow for gas flow;
- one or more glass tubes; and
- a fan,
- wherein the one or more strips and the one or more glass tubes are coupled to the base,
- wherein the one or more glass tubes encapsulate the one or more strips in a heat transfer medium,
- wherein the central vent is disposed adjacent to the one or more glass tubes,
- wherein the fan drives gas flow from the certain ones of the side vents to the central vent, and
- wherein the gas flow from the central vent circulates adjacent to the one or more glass tubes.

8. The LED lighting apparatus of claim **7** wherein the heat transfer medium is gas, and wherein the gas circulates via select ones of the side vents.

9. The LED lighting apparatus of claim **7** wherein the heat transfer medium is a liquid.

10. The LED lighting apparatus of claim **9** further comprising a liquid cooling unit, wherein the liquid is circulated to the liquid cooling unit for cooling, and wherein the cooled liquid is recirculated to the one or more glass tubes.

11. The LED lighting apparatus of claim **7** wherein the heat transfer medium is compressed air.

12. A light emitting diode ("LED") lighting apparatus, comprising:
- one or more strips, wherein each of the one or more strips has LEDs and a transparent backing;
- a base having vents, wherein the vents comprise a central vent and side vents and wherein the central vent and certain ones of the side vents are connected to allow for gas flow;
- one or more glass tubes;
- a fan; and
- a liquid cooling unit,
- wherein the one or more strips and the one or more glass tubes are coupled to the base,
- wherein the one or more glass tubes encapsulate the one or more strips in a liquid,
- wherein the central vent is disposed adjacent to the one or more glass tubes,
- wherein the liquid is circulated to the liquid cooling unit for cooling,
- wherein the cooled liquid is recirculated to the one or more glass tubes,
- wherein the fan drives gas flow from the certain ones of the side vents to the central vent, and

wherein the gas flow from the central vent circulates adjacent to the one or more glass tubes.

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